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BAYER LEVERKUSEN (GERMANY)

Department for Plant Protection

Distribution, Resistance to Rain and Translocation of Spray and Mist Deposits in Potato Stands

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I. Introduction

Now that pesticides can be applied not only by spraying and dusting but also by means of the atomizing and aerosol methods, several problems have been encountered with respect to their biological efficacy. A knowledge of the advantages and disadvantages of spraying and atomizing is of practical importance especially in tillage. It, therefore, appeared essential to carry out a detailed investigation of the efficiency of the spraying and atomizing processes¹⁾.

Once an investigation had been made by means of the paper sheet method used for reproducing a picture of the spray coatings in potato stands, in order to determine both with respect to the spraying process as well as the atomizing process,

1. how the spray wash is distributed in the stand,
 2. whether the abaxial surfaces of the leaves are treated,
 3. whether the spray mist reaches the lower parts of the plants,
- it remained necessary to clarify the following questions:
1. Quantitative distribution of active ingredient in the field stand.
 2. Resistance to rain of the spray and mist deposits.
 3. The translocation of the spray and mist deposits on the leaf and plant.

II. Method

In our investigations carried out to clarify these questions, we employed the methods published by Neuhäus (1952) to determine the copper content in copper spray deposits on plants. In fact it was the potassium ferrocyanide method which was used, a method suitable for determining small quantities of copper. The colorimetric copper determination was carried out with a photoelectric colorimeter, designed by Lange. Primarily to ensure that the third question would also be settled, the distribution of the copper spray deposits and the translocation of the active ingredient on the potato pinnae were examined, this being done by applying the methods of Schwaebel and Obermayer (1951).

The potato pinnae which were to be examined for their copper deposit, were taken from plots treated outdoors by means of field sprayers and atomizers, either immediately after they had been sprayed or following rainfall of varying intensity. The average height of the plants at the time of the treatment was 55

¹⁾ **Spraying:** Droplet sizes exceeding 150 microns. Spray wash is applied through nozzles under a pressure which as a rule is produced by a liquid pump.
Atomizing: Range of droplet sizes between 50 and 150 microns. An air current produced by means of a blower or compressor causes the fine dispersion of droplets, and at the same time serves as the carrier air stream.

to 60 cm. The interval between each treatment and rainfall was so long in all the tests that the spray or mist deposit was able to dry out fully on the plants. The leaves were always dry at the time they were picked. The two factors, amount and type of the rainfall, were measured and determined respectively by the meteorological office at Muenster. The field sprayers and atomizers used in the investigation had an output of 600, 200, 100 and 50 litres per hectare respectively. In each case, 4.5 kg of Bordeaux mixture with a 50 % copper content were sprayed or atomized per hectare. The copper determinations were carried out on a total of more than 10,000 potato pinnae. The individual means were based as a rule on 50 to 250 determinations. The determination of the copper content in the copper spray deposits, and the determination of the copper dispersion on the pinnae were carried out separately for the adaxial and the abaxial surfaces of the leaves. The leaf sizes were measured with a planimeter, and the determined Cu values converted to cm^2 -leaf surface.

III. Distribution of active ingredient in the field stand

a) Cu determinations on the adaxial surfaces of the leaves

In order to determine quantitatively the distribution of copper, and consequently the spray wash distribution in the field stand generally, pinnae were taken from the upper, middle and lower parts of the plants growing in the plots treated with the different types of field equipment. Difficulties were encountered, however, in obtaining a satisfactory colorimetric copper determination on the pinnae of the lower plant parts, firstly because of impurities on the leaves originating from the soil, and secondly because these leaves died prematurely. For this reason no allowance was made for the copper values determined for the lower plant parts. As a rule their order of magnitude is around $1 \gamma/\text{cm}^2$.

In Table 1 (I), the values of the upper and middle plant parts are set off against each other. On comparing the figures it is obvious that when the same quantities of active ingredient are applied in equal quantities of liquid per hectare, differences in the distribution of active ingredient arise between the spraying and the atomizing processes. Such variations are most pronounced in the middle part of the plant, which is treated more thoroughly by the atomizing process than by the spraying process, as shown in the comparison following an application of 200 litres of liquid per hectare. Therefore, when drawing comparisons, a difference always has to be made between spraying and atomizing.

Similar tendencies stand out, however, within the spraying test series and the atomizing series. The quantity of active ingredient deposited on the plant decreases, both in spraying and in atomizing, proportional to the reduction in the quantity of liquid and the consequent interrelated decrease in the size of the droplet, despite the application of equal quantities of active ingredient per unit of area.

The decrease in the copper values following the reduction of the quantity of liquid is particularly noticeable in the middle part of the plant. On comparing these values, the difference between the spraying and the atomizing processes is even more apparent.

The active ingredient distribution ratio of the upper plant parts to the centre plant parts represents a standard for the depth of penetration in the

Table 1: Cu determinations on the adaxial surfaces of the leaves. Cu values in γ/cm^2 .

Removal of foliage	Plant part	Spraying		Atomizing			
		600 l/ha	200 l/ha	200 l/ha	100 l/ha **)	100 l/ha	50 l/ha
I. before rainfall	a) upper	8.2	7.2	7.4 *)	4.9	3.6	4.4
	b) middle	4.4	3.0	5.4 *)	3.1	2.0	1.4
	ratio a : b	1.9 : 1	2.4 : 1	1.4 : 1	1.6 : 1	1.8 : 1	3.1 : 1
II. following light rainfall	c) upper	3.7	2.0	2.0	3.1	2.9	1.3
	d) middle	2.5	2.0	1.4	1.8	1.8	0.8
	ratio c : d	1.5 : 1	1 : 1	1.4 : 1	1.7 : 1	1.6 : 1	1.6 : 1
III. after heavy rainfall	e) upper	0.1	0.5 *)	—	0.8	0.6 *)	1.6 *)
	f) middle	0.6	1.6 *)	—	1.0	1.7 *)	1.9 *)
	ratio e : f	0.2 : 1	0.3 : 1	—	0.8 : 1	0.4 : 1	0.8 : 1

*) Average value ascertained from only 25 Cu determinations.

**) Knapsack atomizer.

Table 2: Cu determinations on the abaxial surfaces of the leaves. Cu values in γ/cm^2 .

Removal of foliage	Plant part	Spraying		Atomizing			
		600 l/ha	200 l/ha	200 l/ha	100 l/ha **)	100 l/ha	50 l/ha
I. before rainfall	a) upper	2.6	2.0	0.7 *)	2.5	1.3	1.5
	b) middle	1.3	0.5	0.7 *)	1.7	0.6	0.5
	ratio a : b	2 : 1	4 : 1	1 : 1	15 : 1	2.2 : 1	3 : 1
II. following light rainfall	c) upper	2.9	0.9	1.5	2.2	1.8	1.3
	d) middle	1.0	1.0	0.7	3.2	0.7	0.8
	ratio c : d	2.9 : 1	0.9 : 1	2 : 1	0.7 : 1	2.6 : 1	1.6 : 1
III. after heavy rainfall	e) upper	0.3	0.1 *)	—	0.6 *)	0.7	0.7 *)
	f) middle	0.3	0.3 *)	—	0.3 *)	0.2	0.6 *)
	ratio e : f	1 : 1	0.3 : 1	—	2 : 1	3.5 : 1	1.2 : 1

*) Average value ascertained from only 25 Cu determinations.

**) Knapsack atomizer.

plant stock, and this varies to the disadvantage of the centre part of the plant when smaller quantities of liquid are applied. However, the proportions which the stimulating effect of the blast air stream can assume with respect to the treatment of the middle part of the plant, are made particularly clear on comparing the ratio for 200 litres per hectare of mist (1.4:1) with that for 600 litres per hectare of spray (1.9:1).

b) Cu determinations on the abaxial surfaces of the leaves

The copper values for the abaxial leaf surfaces are compiled in Table 2 (I). The values ascertained from atomizing at the rate of 200 litres of liquid per hectare are somewhat inconsistent. These are average values obtained from 25 Cu determinations only. If no allowance is made for these values, it follows that there is a drop in the quantity of active ingredient reaching the underside of the leaves when the quantity of active ingredient is reduced both for spraying and atomizing. There was a uniform tendency with respect to the ratio of the percentage of active ingredient in the top third of the plant to the percentage of active ingredient in the middle section on the abaxial leaf surfaces, for the copper quantity to decrease from the top to the middle parts of the plant; the ratio varies proportional to the decrease in the quantities of liquid applied. With respect to the coverage of the abaxial leaf surfaces in the centre part of the plant, atomizing generally produces better effects than spraying.

c) Total distribution of active ingredient

The total copper values ascertained for the upper and centre parts of the plants, which have been calculated by adding the values for the adaxial and the abaxial leaf surfaces, are recorded in Table 3 (I).

Whereas there is a tendency for the Cu values to drop in the upper plant parts, which as a rule is proportional to the reduction of the quantities of spray wash applied, the figures for the middle plant parts again clearly illustrate the effect of the blast air stream in the atomizing process which results in a better treatment of the middle section of the plants. The absolute maximum quantity of active ingredient per 2 cm^2 leaf (abaxial and adaxial surfaces) is deposited at 600 litres per hectare of spray ($10.8\text{ g/cm}^2 + 5.7\text{ g/cm}^2 = 16.5\text{ g/2 cm}^2$), with 200 litres per hectare of mist giving the second best result ($8.1\text{ g/cm}^2 + 6.1\text{ g/cm}^2 = 14.2\text{ g/2 cm}^2$). This is followed by 200 litres per hectare of spray with 12.7 g/2 cm^2 , and 100 litres per hectare of mist with 12.2 g/2 cm^2 . The effect of a reduction in the quantity of wash per hectare, both with respect to spraying as well as atomizing, is clearly seen from the ratio a:b in Table 3 (I). The more thorough treatment given to the middle plant parts by atomizing is wasted by the drop in the quantity of copper actually deposited when the quantity of liquid applied is decreased considerably. The reason for this is the high percentage of suspended particles. This percentage increases proportional to the decrease in the size of the droplets, and particularly as the number of the smallest droplets increases. Very small droplets, under normal conditions, are often unable to break through a layer of air surrounding the leaf. Investigations and calculations (Wöllmer, 1951) have revealed that particles of 1 micron diameter in still air have a falling velocity of 0.05 mm/sec. This means that an upward current with a velocity of only 5 mm/sec. is sufficient to keep a particle of 10 micron diameter in suspension. Assuming the thickness of the air layer — such as it forms around every solid body as the field of current due to microheat — to be only 1 mm, a particle of 10 micron diameter must have

Table 3: Totals of the Cu values on the adaxial and abaxial leaf surfaces in γ/cm^2 .

Removal of foliage	Plant part	Spraying		Atomizing			
		600 l/ha	200 l/ha	200 l/ha	100 l/ha **)	100 l/ha	50 l/ha
I. before rainfall	a) upper	10.8	9.2	8.1 *)	7.4	4.9	5.9
	b) middle	5.7	3.5	6.1 *)	4.8	2.6	1.9
	ratio a : b	1.9 : 1	2.6 : 1	1.3 : 1	1.5 : 1	1.9 : 1	3.1 : 1
II. after light rainfall	c) upper	6.6	2.9	3.5	5.3	4.7	2.6
	d) middle	3.5	3.0	2.1	5.0	2.5	1.6
	ratio c : d	1.9 : 1	1 : 1	1.7 : 1	1.1 : 1	1.9 : 1	1.6 : 1
III. after heavy rainfall	e) upper	0.4	0.6 *)	—	1.4	1.3 *)	2.3 *)
	f) middle	0.9	1.9 *)	—	1.3	1.9 *)	2.5 *)
	ratio e : f	0.4 : 1	0.3 : 1	—	1.1 : 1	0.7 : 1	0.9 : 1

*) Average value obtained from only 25 Cu determinations.

**) Knapsack atomizer.

Table 4: Relative Cu values in percentage (Cu values before rainfall = 100 %).

Relative Cu values		Spraying				Atomizing							
		600 l/ha		200 l/ha		200 l/ha		100 l/ha *		100 l/ha		50 l/ha	
		upper plant section	middle plant section	upper plant section	middle plant section	upper plant section	middle plant section	upper plant section	middle plant section	upper plant section	middle plant section	upper plant section	middle plant section
I.	Adaxial leaf surfaces	100	100	100	100	100	100	100	100	100	100	100	100
		45.1	56.8	27.8	66.7	27.0	25.9	63.2	58.1	80.6	90.0	29.5	57.1
		1.2	13.6	6.9	53.3	—	—	1.6	32.2	1.7	85.0	36.4	135.7
II.	Abaxial leaf surfaces	100	100	100	100	100	100	100	100	100	100	100	100
		111.5	76.9	45.0	200.0	214.3	100	88.0	188.2	138.5	116.7	86.7	160.0
		11.5	23.1	5.0	60.0	—	—	24.0	17.6	53.9	33.3	21.4	120.0
III.	Adaxial and abaxial leaf surfaces	100	100	100	100	100	100	100	100	100	100	100	100
		61.1	61.4	31.5	85.7	43.2	34.4	71.6	104.2	95.9	96.1	44.1	84.2
		3.7	15.7	6.5	54.3	—	—	18.9	27.1	26.6	73.1	39.0	131.6

*) Knapsack atomizer.

a horizontal velocity of not less than 2 m/sec. in order to penetrate the air layer and to be able to settle on the surface of the body. The stronger concentration is of significance in furnishing an explanation for the relatively high loss of active ingredient when using less water in the atomizing process. When 50 litres per hectare are atomized, a suspended droplet contains twelve times the amount of active ingredient held by a droplet of equal size when 600 litres per hectare are sprayed. In the atomizing process, the droplet is given a greater velocity by the air current. This greater velocity of the droplet results on the one hand in the mist penetrating deeper into the plant stand, and on the other hand, it also enables even smaller droplets to penetrate the air layer surrounding the leaf, and to deposit. It must, therefore, be the task of apparatus designers when making atomizers, to harmonize the factors air quantity, air velocity and droplet size to such an extent that a maximum of active ingredient is deposited, and so that losses of active ingredient due to dripping and suspension or drifting are kept to a minimum.

The influence exerted by air quantity and air velocity is shown in a comparison of the two columns of figures given in respect of atomizing at the rate of 100 litres per hectare. The field atomizer had an air output of 1000 litres per min. with an air velocity of 65 m/sec. at the nozzle opening, whereas the knapsack atomizer had an output of 8000 litres of air per minute with an air velocity of 55 m/sec.

IV. Resistance to rain of the copper deposits

To investigate the resistance to rain property of copper deposits, potato pinnae were taken from treated plots after rain had fallen, and the copper deposits were determined quantitatively for the adaxial and the abaxial leaf surfaces separately. In Section II of Table 1, the quantities of copper which withstood light rainfall are given, while in Section III of the same table, those quantities of copper are recorded which resisted heavy rainfall. In the first instance the rainfall was between 0.1 and 2.9 mm, and in the second case there was up to 28.1 mm of shower rainfall. The degree of washing off depended upon the amount of rain which actually fell irrespective of whether these quantities of rain fell in heavy showers over a short period or whether they fell as light rain over a long period. As was to be expected, the upper parts of the plant were exposed to washing off to a greater degree than the centre parts. Consequently the active ingredient ratio of the upper plant parts to the lower plant parts was more balanced. Following heavy rainfall, there was in most cases more active ingredient present in the middle plant parts than in the upper plant parts. As a rule, the spray coating consisting of small droplets proved to be relatively more resistant to rain. For example, the copper quantity for an application of 600 l/hectare decreased from 8.2 γ/cm^2 to 0.1 γ/cm^2 following a fall of rain, while the deposit consisting of small droplets for an application of 50 l/hectare dropped from 4.4 γ/cm^2 to 1.6 γ/cm^2 (Table 1).

In addition to other factors, consideration should be given to the degree of coverage of the spray deposit in finding an explanation for the variations in the resistance to rain. When large quantities of liquid are applied (e. g. 600 litres per hectare), a greater degree of coverage is produced as a rule (Goossen, 1953), which — dependent upon the wettability of the leaf surface — can assume the proportion of a complete film (Linskens, 1951), whereas by applying smaller quantities of liquid per hectare, the coverage of the surface is less with

smaller droplets. Mostly these droplets do not link up directly with each other, even when the plant surface has a good wetting property. In this case, smaller droplets of active ingredient offer the rain a considerably smaller surface of attack. Hö h e n e r (1954) attributes greater resistance to rain to speedier drying with reduced quantities of wash.

The copper determinations carried out on the lower surfaces of the leaves (Table 2, II and III) produced some really interesting results. These are particularly prominent in Table 4. The quantities of copper determined on the abaxial and adaxial leaf surfaces prior to rainfall are set at 100 %, and the quantities of copper determined following rainfall are based on this value. Whereas the degree of washing off on the top surfaces of the leaves is expressed in decreasing percentages, the copper values for the abaxial surfaces are often higher following rainfall than before rainfall. This astonishing fact was established, however, only following light rainfall, whereas heavy rainfall resulted in the copper deposits being considerably washed off on the abaxial leaf surfaces, too. The presence of large quantities of copper on the lower surfaces of the leaves following light rainfall might be explained by presuming that copper deposits on the adaxial surface close to the periphery of the leaf were transported by the water droplets to the lower surface of the leaf where they dried on again.

V. Distribution of active ingredient and transport of active ingredient on the leaf

The investigations on the distribution of active ingredient in the field stand have shown that the copper deposit can be transported not only from one plant part to the other, but also along the leaf or pinna. The translocation of quantities of copper from the top to the lower surface of the leaf is of interest from the aspect of technical control. In order to obtain exact data on the quality of the copper deposits before rainfall, and on the translocation of the active ingredient with the rain, the distribution of copper on the top and lower surfaces of the leaf was subjected to a large-scale study, employing for this purpose the method of Sch w a e b e l and O b e r m a y e r (1951). The evaluation of the leaf impressions obtained was carried out in such a manner that a leaf surface was assessed as being sprayed when the entire leaf blade was densely covered with spray droplets, taking the standard degree of coverage produced by the respective apparatus as the basis. The aim of doing this was to avoid assessing a sprayer with a lower output of wash more unfavourably than a sprayer with a higher litre output per hectare, with respect to the degree of spray coverage. A leaf side was recorded as being $\frac{2}{3}$ or $\frac{1}{3}$ treated when only $\frac{2}{3}$ or $\frac{1}{3}$ of the leaf blade was sprayed or atomized or when spray droplets were distributed over the entire leaf blade, yet the degree of coverage produced was so low that one could merely refer to a $\frac{2}{3}$ or $\frac{1}{3}$ spraying of the leaf surface. Table 5 gives the values for the three sections of the plant, subdivided according to the adaxial and abaxial surfaces of the leaves. These figures confirm the results obtained by means of both the N e u h a u s method and the paper sheet method (G o o s s e n, 1952 and 1953). The diagrammatic representation of the results in Fig. 1 has been made in such a manner that in two rectangles (= 100 % coverage of the leaf surfaces) the $\frac{3}{3}$, $\frac{2}{3}$ and $\frac{1}{3}$ leaf wettings have been entered separately for the adaxial and the abaxial leaf surfaces. This method of illustration shows the outputs of the different apparatus with respect to an all-side wetting. For producing a distribution of

Table 5:

Distribution of active ingredient in the three sections of the plant. Figures expres

Process	l/hectare	Upper section of plant ($1/3$)							
		Adaxial surface treated				Abaxial surface treated			
		$3/3$	$2/3$	$1/3$	$0/3$	$3/3$	$2/3$	$1/3$	$0/3$
Spraying	600	46	36	18	0	0	3	64	3
Spraying *)	500	25	70	5	0	0	45	55	
Spraying	400	33	30	37	0	5	5	77	1
Spraying	200	25	58	17	0	0	25	68	
Atomizing	200	50	40	10	0	2	15	50	
Atomizing **)	100	25	28	40	7	7	15	65	
Atomizing	100	17	37	43	3	0	0	40	
Atomizing	50	32	20	42	6	0	8	46	

*) Special apparatus fitted with additional nozzles which spray in an upward direction, to

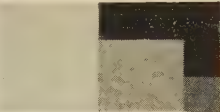
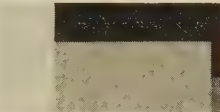
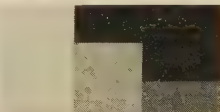
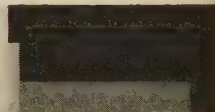
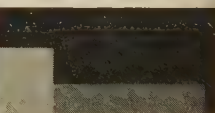
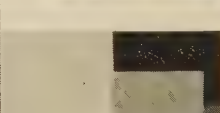
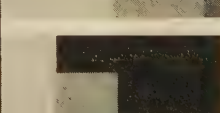
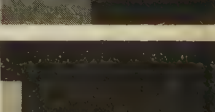
percentages. (Determined according to the method of Schwaebel and Obermayer)

Centre section of plant ($1/3$)							Lower section of plant ($1/3$)							
Adaxial surface treated			Abaxial surface treated				Adaxial surface treated				Abaxial surface treated			
$2/3$	$1/3$	$0/3$	$3/3$	$2/3$	$1/3$	$0/3$	$3/3$	$2/3$	$1/3$	$0/3$	$3/3$	$2/3$	$1/3$	$0/3$
23	36	0	0	0	35	65	15	35	50	0	0	0	25	75
50	15	10	0	20	40	40	25	55	15	5	0	15	35	50
30	30	3	0	10	57	33	—	—	—	—	—	—	—	—
40	48	0	0	0	37	63	20	40	20	20	0	0	40	60
37	37	9	0	2	20	78	20	40	30	10	0	0	20	80
35	50	0	5	5	47	43	25	55	15	5	0	0	45	55
23	57	15	0	0	18	82	10	20	60	10	0	0	0	100
38	48	2	0	2	23	75	10	10	80	0	0	0	0	100

treatment to the abaxial leaf surfaces.

**) Knapsack atomizer.

Fig. 1: Distribution of active ingredient
(Determined by employing the methods

Process	l/hectare	Upper section of plant ($1/3$)	
		Adaxial surface treated	Abaxial surface treated
Spraying	600		
Spraying ¹⁾	500		
Spraying	400		
Spraying	200		
Atomizing	200		
Atomizing ²⁾	100		
Atomizing	100		
Atomizing	50		

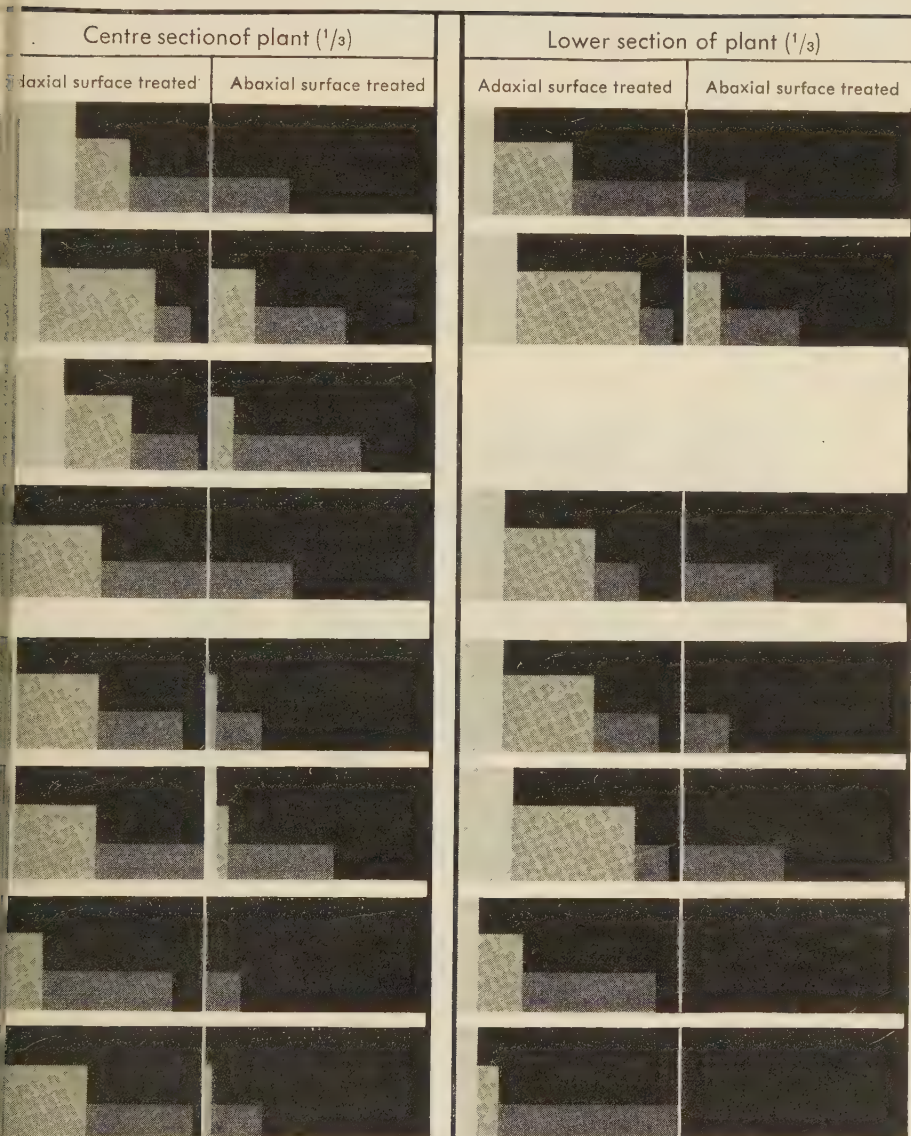
3/3

2/3

1/3

not covered

the three sections of the plant
(Schwaebel and Obermayer)



Special apparatus fitted with additional nozzles which spray in an upward direction, to give better treatment to the abaxial leaf surfaces.
Knapsack atomizer.

active ingredient with a maximum of uniformity and for carrying out a treatment covering as far as possible the entire plant, the most suitable sprayer is one manufactured for test purposes by Messrs. Platz (500 l/hectare). It is fitted with nozzles which spray in a downward direction between the rows. This design, a similar type of which was built as far back as 1910, has not established itself in Germany, although in America. The reason for this may be due to the different spacing between rows. With the narrow spacing between rows in Germany, the nozzles cannot be drawn between the rows when the potato foliage has reached an advanced stage of growth. Consequently little practical importance can be attached to this design in pest control and plant protection. Hilpoltsteiner (1953), however, obtained maximum results when carrying out manganese fertilization through the leaf with additional spraying from underneath. Sprayers with an output adjusted to 600 litres of liquid per hectare are the most effective among those types in practical usage, with respect to producing a uniform distribution of the wash and to obtaining

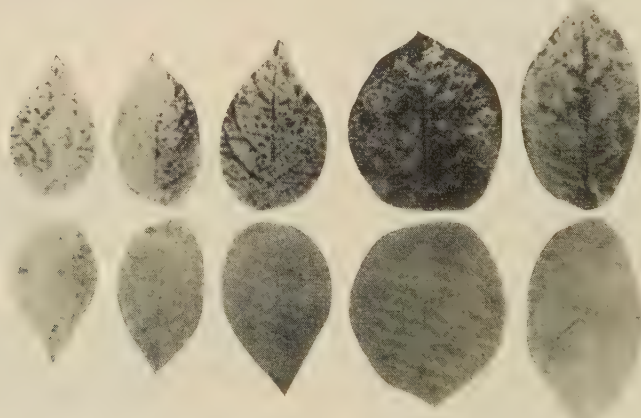


Fig. 2: Copper distribution on potato pinnae of the top section in the plant ($1/3$) after spraying 0.75% copper oxychloride (50% Cu) at the rate of 600 litres of water per hectare. Top row illustrates treatment of the adaxial leaf surface. Bottom row: treatment of the abaxial leaf surface. The spray deposit was not exposed to rain.

a maximum degree of coverage. The wetting effect decreases proportional to reductions in the quantity of wash applied, both in the spraying and in the atomizing processes. The studies carried out on the basis of the method of Schwaebel and Obermayer also confirmed the promoting effect of the blast air current in the atomizing process with respect to the treatment of the centre and the lower parts of the plants.

The determination of the distribution of copper on the leaf following rainfall provided information about the transport of the active ingredient. Figs. 2 to 5 show in the example "600 litres per hectare of spray", that only a part of the active ingredient was washed away by light rainfall. The decrease in the deposit of active ingredient was established chiefly in the base section ($1/3$) of the pinna. A relatively large quantity of active ingredient was only

to be found along the veins of the leaves, at the tips and on the edges. Even following heavy rainfall, the deposit of copper along the leaf veins was still clearly visible. Dependent upon the position of the leaf, it was possible to trace a translocation of the active ingredient deposit along the leaf veins to the tip and the edges. More precise knowledge of the conditions should be useful in providing an explanation for the successes, or even the failures of different pest control measures.

VI. Discussion of the results

The most important result of the studies is the decrease in the quantity of active ingredient deposited on the plants when the quantity of liquid applied and the size of the droplet are reduced. Following these investigations, it will be understood why it is not possible as a rule to economise in active ingredient by reducing the quantity of liquid applied per hectare. Although it has been established in certain cases (e. g. with contact insecticides) that a better effect is obtained by using smaller quantities of liquid (Goossen, 1952), this is to be attributed to finer distribution and, in such an instance, to

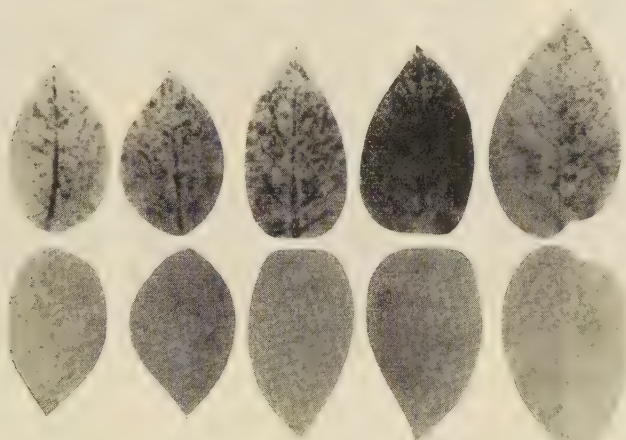


Fig. 3: Copper distribution on potato pinnae in the centre section of the plant ($1/3$).
For test data see Fig. 2.

the more favourable effect of spray deposits composed of small droplets. It could be imagined that in other cases, poorer biological efficacy — with the same quantity of active ingredient, but with a reduced quantity of wash per unit of area — might be remedied by increasing the quantity of preparation applied per unit of area to correspond with the loss of active ingredient.

The point of view often held in the past that with large quantities of liquid (600 l/ha) the losses due to dripping are so great that more active ingredient is deposited on the plants when less liquid is applied, has not been confirmed. In the investigations, it was found that losses due to dripping when 600 litres per hectare are sprayed, are less than the percentage of suspended particles in mist containing small droplets produced by spraying and atomizing. The increase in the percentage of suspended particles when the size of the droplet is

reduced conforms with the laws of physics; the extent of the losses of active ingredient caused surprise. A study which has been published in the meantime (Scharmer, 1954) produced similar results. The quantity of preparation not deposited on the plant when the quantity of liquid is decreased, will only be deposited on fields in the immediate vicinity where it will cause damage dependent upon the nature of the active ingredient. A large percentage of the suspended droplets may remain in suspension for some considerable time, and may even be carried over a long distance dependent upon the environmental conditions, particularly as there is a rapid decrease in weight and size due to the evaporation of the moisture of very small droplets which just the same have a relatively large surface, a condition which makes it even more difficult for the droplets to be deposited on the plants.

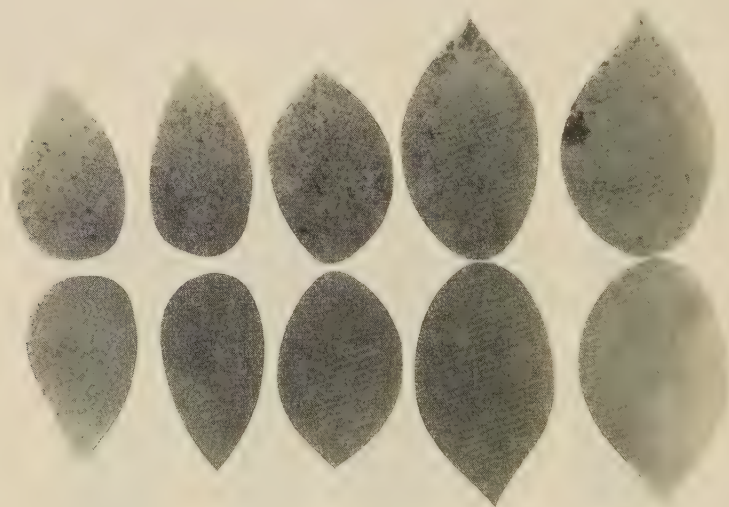


Fig. 4: Distribution of copper on potato pinnae in the lower section of the plant ($\frac{1}{3}$).
For test data see Fig. 2.

The percentage of active ingredient deposited in the vicinity of the treated field should be determined more precisely from the quantitative aspect. It must not necessarily be parallel to the total losses of active ingredient. However, it is probably less when 200 litres per hectare are atomized than when the active ingredient is sprayed at the same rate, although it was proved that when 200 litres per hectare are atomized there is a quantity of active ingredient amounting to 14.2 γ as compared with only 12.7 γ per 2 cm² of leaf surface when wash of the same concentration is sprayed (200 litres per hectare).

The investigations have shown that it is essential to differentiate between spraying and atomizing. The two processes differ in many points both in the distribution of the active ingredient as well as with respect to resistance to rain. It is not only the quantity of wash applied per hectare which governs the success or failure of a control measure from the technical aspect, namely from the point of view of the apparatus used; the application process is of greater

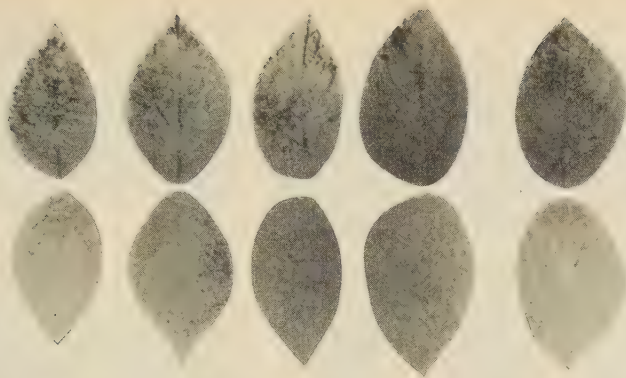


Fig. 5: Distribution of copper on potato pinnae in the centre section of the plant ($\frac{1}{3}$) following light rainfall.
For further test data, see Fig. 2.

importance. An inadequate effect after spraying 200 litres per hectare does not mean that the application of 200 litres per hectare by means of the atomizing process will also prove unsatisfactory.

A result of importance for the industry manufacturing apparatus for pest control is the finding that it is not enough merely to decrease the size of the droplet proportional to reductions in the quantities of liquid applied. Each decrease in the size of the droplet must be accompanied by an increase in the velocity at which the droplet leaves the nozzle. With small droplets, it will then only be possible to apply active ingredient to the plant in large quantities when the smaller size and the lower weight of the particle can be balanced by greater velocity and an improved power of penetration imparted to the liquid droplets.

It is above all essential in the construction of atomizers to place air velocity, quantity of air and droplet size in the correct ratio. Interesting test results

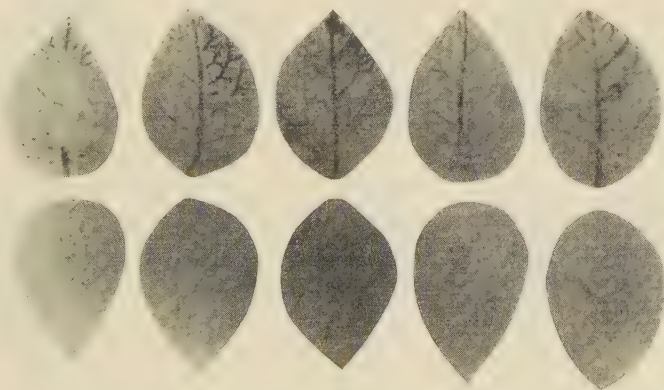


Fig. 6: Distribution of copper on potato pinnae in the centre section of the plant ($\frac{1}{3}$) following heavy rainfall.
For further test data, see Fig. 2.



Fig. 7: Distribution of copper on potato pinnae in the top section of the plant ($\frac{1}{3}$) following light rainfall.
For further test data, see Fig. 2.

in respect of these questions have been published by Yeomans and Rogers (1953).

A one-sided, exaggerated reduction in the size of the droplet (Goossen, 1953) is definitely wrong for the control of plant diseases and such pests present on the plants which have to be combatted there. The conditions applying to the control of insects which are able to fly (e. g. mosquitoes) might be different at times. In such cases, a droplet size which guarantees long suspension may be of advantage.

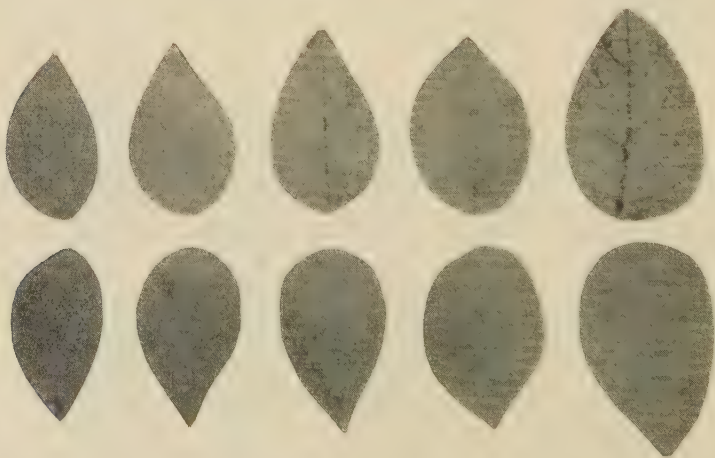


Fig. 8: Distribution of copper on potato pinnae in the top section of the plant ($\frac{1}{3}$) following heavy rainfall.
For further test data, see Fig. 2.

Regarding the question of resistance to rain, sprayed and atomized deposits consisting of small droplets proved to be superior to large droplets. It still remains to be decided whether the greatest possible resistance to rain should be strived for in every case. One can well imagine that in those cases where it is desirable for the active ingredient to be transported to the base of the plant or the lower plant section, sprayed and atomized deposits which are extremely resistant to rain might have an unfavourable effect.

VII. Summary of the most important results

1. Absolute Cu values were determined — this was done separately for the abaxial and adaxial leaf surfaces — on pinnae taken from outdoor plots treated with sprayers and atomizers.
2. To determine the distribution of active ingredient on the pinna, and a transposition of the deposit on the leaf due to rain, impressions were made of potato pinnae by means of the method of Schwaebel and Obermayer (1951).
3. Spraying and atomizing processes differ in many points, although similar tendencies were observed in both processes as soon as a start was made to economize in the quantity of water applied.
4. A better distribution of active ingredient was attained in the atomizing process, using the same quantity of active ingredient and liquid as that used in the spraying process.
5. When the same quantities of active ingredient are used in varying quantities of liquid, far less active ingredient is deposited on the plant when smaller quantities of water are applied accompanied by smaller droplets.
6. The depth of penetration of the sprayed and atomized mist decreases proportional to reductions in the quantity of liquid applied.
7. With respect to resistance to rain, the Cu deposit consisting of small droplets proved to be superior to that made up of large droplets.
8. The top section of the plant is more exposed to washing off by rain than the other parts, which explains why the change in the active ingredient ratio is in favour of the centre part of the plant, as the result of rainfall.
9. A translocation of the active ingredient from the adaxial leaf surface to the abaxial surface was observed following light rainfall.
10. The active ingredient is translocated along the leaf veins, a process which depends upon the position of the leaf.

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The Organisation of Beet Leafhopper Control in East Lower Saxony

Example of the progress of a large-scale control (1949—1954)

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1. Introduction

The beet leafhopper (*Piesma quadratum*) is the carrier of a dangerous virus disease, the beet leafhopper-curly top of sugar beets and mangels. It is not intended to discuss the appearance, biology and nature of the damage caused by the beet leafhopper in this paper. Wille (7), Kaufmann (3) and Nitsche (5) have already reported on this. Nitsche (6) and Mayer (4) have in fact reported on the controls of the beet leafhopper carried out during

the regime of the former German Reich. The standard of the control measures carried out in those days is indicated in the work "Guiding principles for the control of the beet leafhopper" published by the former Reich Biological Institute (8).

2. Occurrence in the Federal Republic

All control over the occurrence and penetration of the beet leafhopper was lost due to the second world war. Consequently beet leafhopper-curly top was allowed to spread freely to the fields of the present-day Federal Republic during the last few years of the war. The Department for Pest Control, re-established at the end of 1945 in Lower Saxony, conducted a series of investigations to determine the extent and intensity of the infection, and thus laid the basis for later control. In 1948, conditions had reached such a level that in a number of sub-districts located in the frontier regions of Helmstedt and Gifhorn, the beet yields of many fields had dropped considerably due to the occurrence of curly top transmitted by the beet leafhopper. Yields of 1250 to 2500 kg of sugar beets per 2500 sq.m. were frequently harvested and on good soil with an appraisal figure of approximately 80, crops totalling 3250 kg of beets were picked per 2500 sq.m. It was during this particular year that we commenced our field test controls of the beet leafhopper with chemical preparations.

3. Control tests with chemical preparations

Whereas all reports received up to this particular year only referred to failures resulting from the application of chemical preparations, it was decided to make use of insecticides which had just appeared on the market in an effort to successfully combat the beet leafhopper by carrying out the applications at the time of its migration in Lower Saxony. The preparations applied in our tests were "HCH" Dust and "E 605" Dust. "DDT" was omitted because we had learned from field workers that they had not been successful in obtaining any kills of the hopper even by applying high doses of "DDT" Dust.

The result of these first exploratory tests was most satisfactory; the application of "HCH" Dust even at the high rate of 40 kg per hectare (40 lb/acre) did not give a 100 % kill of the beet leafhopper after 24 hours. In fact on those parts of the plots which were powdered white due to the faulty operation of the equipment, many hoppers, even though seriously affected, were still alive after 24 hours. "E 605" Dust, on the other hand, also when applied at the lower rate of 16 kg per hectare (16 lb/acre), produced a 100 % mortality after 24 hours. We were now ready to start our control.

Later tests which were run over a period of six years up to and including 1954, and in which we tested a large number of new insecticides — also systemic preparations — clearly proved that not one of these preparations came up to the standard of "E 605" Dust in their effect, in fact not even when the active ingredient was strengthened considerably in certain cases. The effect of "E 605" Dust was always so good that we used it as the standard pesticide in our subsequent tests. Even doses as low as 8 kg per hectare (of course every row was treated) led to a 100 % kill of the beet leafhopper. In contrast to "E 605" Dust, "E 605" conc. applied at the same rate — and even at double strength — did not bring us the same degree of success, and what was more important, kills in the same degree of regularity. Our tests brought another good property of "E 605" Dust to light, namely it proved to be more persistent than previously established. Whereas it had been stated in the past that "E 605" Dust

remained effective for only 24 hours due to the high vapour tension, we definitely established in our tests that in Spring (beginning of May) — even at the time when the migration of hoppers was greatest — beet leafhoppers were not to be found again on the treated plots, as a rule, until six days after the application. We attributed this to the low temperatures prevailing at the beginning of May — in particular the night temperatures — which resulted in the vapour tension being reduced, furthermore to the fact that “E 605” Dust only covered the young beet plants which had just emerged, to a very slight degree. The greater part of the dust fell on the soil where it remained effective for a long period against the beet leafhopper. Mention ought to be made at this point of another observation. Even where there were 100 hoppers per running metre of beet rows in fields with a heavy infection of curly top, we succeeded in keeping the number of beet plants which became diseased with curly top down to a very low percentage, or even a fraction of one percent, on the treated plots by applying “E 605” Dust several times. On the untreated parts — and also in the centre parts of the fields which are actually less exposed to the danger of infection — there were in contrast, several times as many plants which were suffering from curly top. This may be attributed to the fact that only a certain number of the hoppers were infectious, and that these insects just at this time (migration and mating) were extremely mobile. They were killed while migrating on to the treated plots, and the mass infection was arrested. On the other hand, the very weak hopper infestation on the untreated plots which were less exposed to danger, had a devastating effect.

4. First control period 1949—1952 (1953) — Trap strip dusting

The old method of ploughing up trap strips employed from 1936 to 1939 could only be enforced with the aid of police supervision in the former German Reich. The beet growers were obliged to violate knowingly the otherwise conventional laws of cultivation. By tilling late — often 6 to 8 weeks too late — considerable yield losses of beets, foliage, pulp and sugar had to be borne. As this was no longer possible after 1945 — in fact the police could no longer be called upon to supervise pest control measures — Fischer (1), who was the head of the Pest Control Department in Hanover at the time, recommended the adoption of the trap strip dusting process in the control area of the beet leafhoppers, a method which later became obligatory in that area as the result of a police regulation being issued in Lower Saxony (9). By employing the trap strip dusting method, the early sown “trap strips” (end of March/beginning of April) — on which the beet leafhoppers were to collect (to be trapped) — no longer had to be ploughed, as in the past, at a time when the last of the hoppers had immigrated. On the instructions of the Pest Control Department, the strips — like the adjoining area of grass and broom — were dusted at the beginning of the immigration (beginning of May), and again about 6 to 7 weeks later, and did not have to be ploughed again. It was not until these measures had been taken that the remainder of the field could be tilled. Consequently this was generally done between May 6 and 9, about 2 to 3 weeks earlier than was the case with the old method. Naturally, we made a particular point of keeping a very careful check during our investigations on the desertion of the winter quarters of the beet leafhoppers and the migration of the pests to the beet fields. This was done by making daily counts. Immigration by the winged stage was studied by means of glue boards, and we, too, found that this only occurred at temperatures of over 18° C in the shade.

The trap strips used in the trap strip dusting method were treated with "E 605" Dust at the rate of 20 to 30 kg/hectare (20—30 lb/acre) applied with knapsack or motor dusters. It was proved in our tests that it is quite sufficient simply to treat every other row with the knapsack duster. The Schulze-Eckel motor duster, the conventional type used in this area, has a swath of 5 metres. These control methods, employed in the districts of Helmstedt and Gifhorn, and later in Peine and Braunschweig, were extremely successful. In those heavily infected sub-districts which were given treatment, the number of hoppers determined every Spring decreased rapidly. Whereas at first it was by no means a rarity to encounter more than 100 hoppers per running metre of beet rows, we found at the end of three years, during which time the sub-districts had carried out controls most meticulously, that there were only odd cases of hoppers occurring in the fields. Even the curly top carried to the beets by the hoppers had subsided most considerably in these districts, and in certain parts only slight traces of the disease were to be seen. A description of the first control in Lower Saxony is given in the work of Horn (2).

From 1951 onwards, we employed checkers to determine the occurrence of beet leafhopper-curly top, and the success of the control. — The owners of the fields were not obliged to make reports as according to the regulation issued. Moreover they were not at first familiar with beet leafhopper-curly top, and what was more they did not know the leafhopper. — The work entailed a close examination of approximately 15,000 hectares of sugar beet and mangel fields in each district. The task of the checkers was to cover all beet fields in July and August, and partly in September. They were given detailed instructions on their duties, and attended lectures (with lantern slides and photographs) lasting a whole day which were given by our department. Later we ourselves supervised the work of the checkers. They met every week to discuss their work, and to report on the propagation of the beet leafhopper and curly top, and the difficulties they had encountered. These meetings were held under the leadership of the competent extension service technician. This enabled all difficulties to be smoothed out as quickly as possible. In special cases, the checkers had to report to the Pest Control Department by letter, or in an emergency by telephone. The duties of the checkers are outlined below:

- a) Determination of curly top infection in each treated subdistrict in accordance with the specified method (Form 1). They worked in close cooperation with a person well acquainted with the locality (employee of the local authority) who gave them information.
- b) Destruction of beets slightly infected with curly top by means of a hoe. Dusting of hoed-out beets and beets left lying around, also the area round about, by means of the knapsack or hand duster supplied to them. The result was that both the curly top diseased beets and the infection vectors (beet leafhoppers) were killed. Our observations showed that the beet leafhopper larvae, and later the adult hoppers settled chiefly on the curly top infected beets and in their immediate vicinity. In other words they remained close to the place where they hatched out. "E 605" Dust was also supplied to the checkers.
- c) To inform the local authorities of serious infections. The local authorities then supplied workmen to carry out the dusting and the other work described in b) under the supervision of the checkers. The large number of checkers employed (51 to 78) necessitated strict supervision on our part.

The remarks made above about the success of the trap strip dusting method refer solely to those sub-districts in the control area in which the occurrence

of beet leafhoppers was so heavy that responsibility could be accepted for the application of the trap strip dusting process.

Table (Form) 1: Beet leafhopper observation service.

Daily report for

(A report is to be submitted every day)

Place:

Ref. No. of Field	Size in hectares	Infection*)	Name of owner **)
1			
2			
3			
etc.			

*) Infection to be indicated as follows:

0 (figure) — no infection

Tr — traces, i. e. only single diseased plants in the stock

1 — Weak infection: 1 diseased plant per 3 to 10 metres of beet row

2 — Medium infection: 1 diseased plant per 1 to 3 metres of beet row

3 — Heavy infection: 1 diseased plant and more per 1 metre of beet row

The first fifty metres of the field are to be examined to determine the degree of infection.

**) It is only necessary to give the name of the owner when reporting infection 2 or 3.

Unfortunately, growers had to bear certain yield losses even with this method due to the field having to be tilled twice (first the trap strips and then the remainder of the field), and in particular because the rest of the field was sown relatively late on in the season. It was possible to keep these losses down to a minimum by constantly ploughing the untilled parts of the fields (prevention of water vaporization and weed killing).

We found, however, that some growers did not fully appreciate these measures, particularly as they were very keen to carry on tilling their beets.

The costs of employing the trap strip dusting method are given in Table 2:

Table 2: Costs of the beet leafhopper control carried out by means of the trap strip dusting method 1949 to 1953.

Year	hectare	„E 605“ Dust		Equipment		Spotters		Checkers		Total DM
		kg	DM*)	No.***)	DM	No.	Costs DM	No.	Costs DM	
1949	4048	32000	47000	290	13000	—	—	—	—	60000
1950	4000	34267	51400	—	—	—	—	—	—	51400
1951	3084	23240	34860	244	11000	—	—	39	24375	70235
1952	3500	53220	79830**)	62	2800	18	6300	78	54600	143530
1953	650	9880	14820	—	—	4	1400	5	3500	19720

*) Purchase price for “E 605” Dust fluctuates.

**) In certain cases, whole areas were treated from 1952 onwards which explains the large quantities of “E 605” Dust applied.

***) Knapsack dusters.

N. B. In the given hectares of beet rows, only the peripheries of the fields (trap strips) and the immediate vicinity in a width of at least 5 metres were treated.

The above-mentioned yield losses caused by the application of the trap strip dusting method are given in Table 3.

The sum which the control measures actually cost is given in Tables 2 and 3, added to which are the costs of dusting etc. (wages etc.). The observation service has been in operation since 1951, and the control service since 1952.

Table 3: Yield losses arising out of the trap strip dusting process.

Year	District	No. of sub-districts	Treated sugar beets and mangels in hectares	Loss*) (DM 400 per hectare)
1949	Gifhorn Helmstedt	} 88	4048	1 619 200.—
1950	Gifhorn Helmstedt	} 85	4000	1 600 000.—
1951	Gifhorn Helmstedt	} 65	3084	1 233 600.—
1952	Gifhorn Helmstedt Peine	} 72	3500	1 400 000.—
1953	Gifhorn Helmstedt Peine	} 13	650	260 000.—

*) Losses per hectare due to late tillage of the remainder of the fields in the trap strip dusting method: Average loss ascertained from experience at DM 400.— per hectare, slightly more for sugar beets, slightly less for mangels. Cultivation of sugar beets in approximately 75 % of the total area.

5. Second control period 1953—1954

Dusting of periphery strips and the treatment of whole areas

Whereas the measures proved most successful in the actual control area, the beet leafhoppers continued to spread in the so-called observation area which was also covered by the aforementioned police regulation issued for Lower Saxony, in other words the adjoining area with weak infestation which was not under obligation to carry out controls. We often found it necessary to declare a part of the observation area as a control area. We were continually faced with the difficult question as to whether there was any justification in carrying out a control which was so costly and which involved such hardness to agricultural circles. As our farmers applied this method very much against their will when the degree of infection was only slight, we had tested a new method in 1951 — periphery strip dusting or treatment of whole areas — which from 1953 onwards took the place of the method previously employed provided very heavy infections did not make it necessary to revert to the original method. The periphery strip dusting method, or treatment of whole areas, now replaced the original trap strip dusting method in the control area too, whenever it appeared necessary to carry out a further treatment and when the infection was not too severe.

From this time onwards, the entire beet fields could be tilled in the proper season. The Extension Service (Pest Control Department), however, notified growers of the dates for carrying out periphery dusting, based on exact observations. In this case too, adjoining areas of grass and broom were treated as before. In fields particularly exposed to infection which adjoined the winter quarters of the beet leafhopper (edges of woods, ditches, embankments etc.), dusting was not merely restricted to 5 metre wide strips but instead the fields were treated to a depth of 50 metres. Following the two periphery dustings, the beet growers were then instructed at the proper time when to carry out a third periphery dusting or a treatment of the whole field.

This method of control produced extremely good results. It was also possible to apply it in sub-districts where there was only slight infection without any really great difficulties being encountered. The method was further improved in 1954. We switched over to "aimed" control, i.e. after carrying out periphery dustings in all beet fields located in the endangered area (control area as according to the regulation issued), two further periphery dustings, or one to two treatments of the entire fields dependent upon the rate of the winged stage migration, were carried out only at those locations in which beet leafhoppers had been detected. The investigations were carried out by "beet leafhopper spotters".

The spotters were also trained and supervised by the Extension Service. They were employed for four weeks at the time of the migration of the beet leafhoppers to the beet fields, from about the end of April until the end of May. The sugar factories also assumed the responsibility for these workers. They kept a check on approximately 100 to 200 hectares of sugar beet and mangel fields, dependent upon the degree of infection in the previous year. The form used by the "spotters" for the daily reports is shown in Table 4.

Table (Form) 4: Report form for "beet leafhopper spotters".

District:	Spotter:		Date:	Time:	
Sub-district:					
Owner of field	Treated beets in hectares		"E 605" Dust in kg	Cultiv. by	Sugar factory
	Sugar beets	Mangels			
	Peri- phery	Whole field	Peri- phery	Whole field	

The duty of the "spotters" was also to report the degree of infection, namely the occurrence of hoppers per running metre of field periphery and field centre, giving details of the exact location in the sub-district. The establishment of this organisation had an extremely favourable effect on the outcome of the control measures, and led to considerable saving. The infection was detected in good time by the "spotters" so that counter measures could be taken. The "spotters" were of greater importance for the success of the beet leafhopper controls than the checkers because their employment in Spring is most decisive, and if the control is not carried out at the beginning of the year it cannot be made up for later. The infection of the beets is made manifest about 4 to 12

weeks later in the form of curly top occurring on the beet leaves (beet leafhopper curly top). Table 5 gives details of the expenditure incurred in the beet leafhopper control campaign carried out from 1953 to 1954.

Table 5 shows that following considerable reinforcement of the control service in the beet fields, the consumption of chemical preparations for control dropped to a very great extent in 1954. Despite higher wages, it was thus possible to reduce the costs of the beet leafhopper control drive considerably.

Table 5: Costs of the beet leafhopper control 1953—54, carried out by means of periphery and field treatments in the districts of Braunschweig, Gifhorn, Helmstedt and Peine.

Year	Beets in hectares	„E 605“ Dust		Spotters		Checkers		Additional working hours for local labour DM	Total costs DM
		kg	DM 1.50 per kg	No.	DM 350 each	No.	DM 700 each		
1953	13 951	186 981	280 471	34	11 900	46	32 200	23 000	347 571
1954	14 906	150 991	226 486	83	29 050	61	42 700	19 500	317 736

Control and observation area supervised by checkers

On comparing the sums of Tables 2 “costs” and 3 “yield losses” with Table 5 “costs 1953—1954”, it will be seen that the total costs have been considerably reduced as a result of the periphery strip dustings carried out in the last two years (treatments of whole fields where necessary), and in particular as a result of the “aimed” control carried out recently (cf. Table 6).

Table 6: Comparison of the total costs.

Year	Total costs DM	Treated in hectares*)	Total costs per hectare/Average (Costs and losses)
1949	1 679 200.—	4048	415.— DM
1950	1 651 400.—	4000	413.— „
1951	1 303 835.—	3084	423.— „
1952	1 543 530.—	3500	441.— „
1953	627 291.—	6911	91.— „
1954	317 736.—	5587	57.— „

N. B. Expressed in round figures.

*) Only those areas are quoted in which the sugar beet and mangel fields were treated, either by treating the whole field or by dusting the peripheries. Only a part of the supervised sugar beet and mangel fields, as per Table 5, was treated (aimed control).

6. Conditions for the success of a large-scale control

a) Regulations

The realistically minded farmer can always be persuaded of the necessity of carrying out controls — large-scale campaigns — against dangerous pests to maintain or increase his harvest yields, by discussing such problems with him or by means of explanatory lectures. We at any rate must acknowledge this fact because we have always found understanding and cooperation among our farmers. But at each discussion we were always faced with the uneasy question: How do we obtain the co-operation of those who do not attend the meetings and therefore cannot be convinced of the necessity of controls, and also the cooperation of the large number of very poor small-scale growers and farmers? The same applies to the part-time farmers and growers living on the outskirts of large towns and cities who only too often have to economize very carefully and who are reluctant to carry out control measures, even though they realise they are a necessity, because they know that the work means an extra financial burden to them. At every meeting there is always someone who appeals for a regulation to be issued which will compel everyone to carry out control measures. A regulation is admittedly the legal basis for a large-scale control drive but its value should not be overestimated. The regulation alone does not guarantee that whatever is demanded will be fulfilled. It is not until we have convinced those concerned of the rightness and the necessity of the required measures, and have gained the complete confidence of all that we can expect full co-operation to be given. Every effort should be made to get the farmers to do this work voluntarily because they are convinced it is a necessity, and the regulation, the enforcement, must be kept right in the background for cases of extreme emergency. Quite apart from this, it is not easy to persuade the competent local authorities to impose a small penalty against offenders who do not play their part in the control of pests. As a result of the regulation, however, the control becomes an "order". It contains the "instruction" which can be given by the Pest Control Department.

b) Information

During the winter months we always instructed farmers and growers on the application of control methods at afternoon meetings held in the sub-districts, which were preceded by short lectures amplified by the showing of lantern slides and substandard films which were made with the kind cooperation of the Federal Biological Institute and placed at our disposal. As far as possible, we visited all the sub-districts concerned. 131 meetings of this type were the most we held in one winter. They entailed a great deal of effort and sacrifice on the part of the members of the Branch Office of the Extension Service but they formed the main basis for the success of our work. A few days before the start of the actual control, articles were published in the daily press for the benefit of farmers, which were devoted to the beet leafhopper, its hazards and the possibilities of controlling it. Warnings were sent out to the sub-districts with the request to announce them to the general public as the last call to start control measures. Each year we arranged visits to the infected areas, and up to 600 persons participated. In order to transport all these people, we approached the sugar factories for co-operation, and at our request they placed omnibuses at our disposal. These visits to the infected areas had a most impressive effect. We were given valuable assistance in carrying out our important preliminary work by all local authorities, and in particular by the farming

community and the advisory associations. I should also like to make special mention of the great assistance given to us by the management of the sugar factories while we were carrying out the control.

c) Organisation

As it was our intention to make enquiries about the equipment available in the sub-district and to discuss the organisation of the control drives at the afternoon meetings held in Winter, we had to make every effort to raise the interest of as many beet growers as possible and to persuade them to attend these meetings. We proceeded as follows. After making arrangements with the district authorities and the owner of the restaurant where the meeting was to be held, invitation cards were distributed among the beet growers. At our request, the local burgomaster or clerk of the local council instructed one of the council employees to deliver the invitations to the growers personally, and often a receipt of delivery was signed so that we knew who had received them. This proved to be most effective, and very often every beet grower, even including owners of small-holdings, in the respective district attended the meeting. Those attending, and also the local council acting on our advice, were then able to reach immediate decisions about the purchase of equipment and insecticides. An opportunity was also given to discuss all details of the control measures and reference was continually made to the warnings which represented the final summons to start the control.

Stress was always laid on team-work, and preparations were made on this basis. Wherever the local authorities or the growers did not assume responsibility for carrying out the control measures, this task was placed in the hands of the growers' association or the local dealers, provided they owned a motor duster or some other type of large movable duster. At least one of these machines had to be available for each 60 to 70 hectares of beet rows. Portable motor sprayers were transported by mounting them on the front of a horse-drawn cart or on a boom behind a light tractor. We found that it was not advisable to contract large firms to carry out the beet leafhopper control, and in fact we turned down this alternative, because the success of this work, which must be started everywhere at the same time and on the minute, can only be guaranteed by having a large number of machines ready for use at all points. The dust was bought at wholesale price from the associations, the trade or the sugar factories. It was not an easy matter always to find labour to do the work of the spotters (Spring employment) and the checkers (Summer employment). Some were sent to us by the sugar factories which also assumed the responsibility for these men, for which we were most grateful, and we had to find others ourselves. Another regrettable fact was that replacements had to be found even during the actual control period. The farmers, however, always stood us in good stead and we owe much to them for sacrificing their valuable time to help us with this work. These men always cooperated well with the employees of the local authorities who were familiar with the locality.

7. Propagation of beet leafhopper curly top at present

At the beginning of this paper, the districts of East Lower Saxony were referred to as the area of infection. These were the four northern districts of the Branch Office, Braunschweig, attached to the Department for Pest Control, Hanover, first colonized by the beet leafhopper at the time. In 1949, there were only two sub-districts outside this area which were so heavily

infected that they had to be declared control territory. In fact this territory remained a centre point of control during the following years. Even in 1952 large-scale controls still had to be carried out in 87 % of the sub-districts of these regions; branch offices located north and west of Braunschweig covered the remaining 13 % of the sub-districts. In the area covered by our Braunschweig Branch Office, such a high standard had been attained by the Autumn of 1954 that the infection had subsided considerably as a result of the control measures. A list of the reports submitted by the checkers from 1951 to 1954 is given in Table 7.

In cases where there were still fields showing the heaviest degree of infection (rating 3) in one of the sub-districts, this could in all probability be interpreted as being due to a failure on the part of the equipment. Otherwise failures were only encountered as a rule in sub-districts where against our recommendations there had been no team-work, and everyone had worked on his own. The control measures are then wasted, and when this happens in a large number of sub-districts, they can no longer be supervised by a "spotter" or one of our few extension service technicians. The most pleasing discovery made during our investigations in the Autumn of 1954 was, however, the fact that there were hardly any beet leafhoppers present even on plants still suffering from curly top, of which there were also relatively few. Just the same great vigilance must be maintained even here, and prophylactic and "aimed"

Table 7: Occurrence of beet leafhoppers 1951 to 1954. No. of fields and degree of infection.

District:	Year	0	Tr	1	2	3	Total:
Braunschweig	1951	—	36	13	8	8	65
	1952	2212	174	23	9	—	2418
	1953	2876	176	8	—	—	3060
	1954	2115	249	3	—	—	2367
Gifhorn	1951	3416	1794	218	893	258	6579
	1952	2648	3425	978	435	148	7634
	1953	4529	3046	477	178	110	8340
	1954	4746	3463	464	122	53	8848
Helmstedt	1951	1093	803	642	153	29	2720
	1952	1995	993	202	56	26	3272
	1953	1275	775	317	103	69*)	2539
	1954	1800	1214	29	4	4	3051
Peine	1951	611	100	237	88	2	1038
	1952	776	407	285	81	38	1587
	1953	1167	527	73	20	15	1802
	1954	1360	627	40	2	2	2031

*) General drop in the degree of infection 1953 also observed in the district of Helmstedt. It was merely in the region of Vorsfelde that there were several sub-districts still heavily infected by curly top due to poor work carried out by a large firm. In 1953 there were serious reoccurrences in certain frontier sub-districts, which in 1952 were so weakly infected that we had thought it would not be necessary to conduct a general control in 1953.

control measures must be continued. There was one exception in our investigations, namely the frontier region comprising the districts of Helmstedt and Gifhorn, where the beet leafhopper occurred more or less on a large-scale in 1954, particularly in the immediate vicinity of the zone frontier. We attribute this to the fact that alate hoppers continued to fly into the area late on in the season, as established, i. e. after the control measures had been completed. It seems that the beet fields east of the zone frontier are not tilled so early as those on the western side of the zone frontier, judging by the dates on which cultivation work was carried out during the past few years. Tillage of the beet fields starts here about March 15. When there is a lack of plant hosts, the beet leafhoppers continue to fly until they find hosts. This fact and the very strong east wind which prevailed for several weeks in 1954 would appear to provide the answer to the serious occurrence in the area of the zone frontier. Occurrences on such a large scale were not observed in other years. We are left in no doubt whatsoever that the beet leafhopper, which has wings and can fly, is carried by the strong east winds blowing in Spring because it is a very fragile insect. We also believe that the rapid propagation of curly top transmitted by the beet leafhopper from East to West (Silesia to Westphalia) is due to this fact.

Apart from a few exceptions, the propagation of the beet leafhopper in the area being reported on has been more or less completely arrested on the light soil approximately 10 to 12 kilometres north of the heavy soil. The credit for this must be given to the people who carried out the control measures so thoroughly, and in particular to the checkers who recognised the diseased (curly top) plants in good time and killed them. Moreover they also exterminated the beet leafhoppers (infection vectors) populating the diseased plants and the immediate vicinity. Our farmers are keeping a close watch on the occurrence of the beet leafhopper, and are reporting their observations to us. The warning given to the farmers and growers by the occurrences in the neighbouring northern and eastern region, where we conducted the tours, had its desired effect.

8. Summary

1. The complicated trap strip ploughing method for controlling beet leafhoppers, which involved very high yield losses, and which was employed in the thirties, was simplified and made less expensive.
2. At first the trap strip dusting process, which involved far smaller losses, was applied. This was then replaced by the periphery strip dusting method or the treatment of whole areas, which took the form of "aimed" controls.
3. The use of effective chemicals was a condition for the application of this method. In this, "E 605" Dust proved to be superior to all other preparations.
4. The temporary employment of helpers — in particular spotters in Spring and checkers in Summer — proved to be most effective, and was later found to be absolutely essential.
5. It is most important to arrange for comprehensive instructions to be given to all taking part to ensure the smooth progress of a large-scale control drive.

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Systemic Insecticides and Bees*)

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Systemic insecticides are absorbed by plants and are circulated in the plant system by the sap stream so that consequently it might be feared that the poison will contaminate the nectar, especially as the active substance remains in the plants for some weeks.

Should this be the case, there is the danger that bees and other pollinating insects will be poisoned, particularly if these insecticides are applied close to or during the blossom period. In order to clarify this question, several experiments were conducted with two different systemic insecticides, "OPMA" and "Systox".

The firms manufacturing these preparations both claimed that they are harmless to bees and other beneficial insects without, however, furnishing any experimental proof.

*) Submitted for print at the end of January 1954.

"OMPA" is said to have only a slight effect as a contact poison on insects which are directly hit by the spray whereas it is just the opposite with "Systox" which has a strong toxic effect on bees when acting as a contact poison.

With respect to the honey-bee, it has been specially pointed out that "OMPA" does not exert any effect as a contact poison (Ripper et. al. 1949).

Experiments with "OMPA"

(contains 66 % of an organic phosphorus compound:
bisdimethylaminophosphonous anhydride)

Acting as a stomach poison, "OMPA" proved to be highly toxic to bees in comparison with other agricultural sprays. After a short period of starvation, the bees were each fed with 10 mm³ of "OMPA" dissolved in sugar water. The bees were fed individually by means of a microsyringe. Concentrations of 0.07 to 0.74 %, such as are recommended for the practical application of the spray were used, and in every case they caused 100 % mortality within 24 hours.

In order to establish whether the nectar from the flowers of treated plants is poisoned, a number of experiments were conducted outdoors with lilies (*Liliaceae*). The species selected for this purpose were *Hosta japonica* and *Lilium regale*. These plants yield rather large amounts of nectar, and in fact are plants which in practice may be treated with the spray. The *Hosta* plants were sprinkled with 0.05 % "OMPA" from a water jug (half the strength recommended for field applications). The preparation was applied in such a manner that only the lower leaves and the soil were wetted, care being taken that the spray did not fall on the flowers which were in blossom at the time. Moreover the flowers were raised on long stems, and had a long, narrow corolla tube.

On the 5th and the 11th day after sprinkling, the nectar was withdrawn by means of a capillary tube, precautions being taken not to injure the plant tissue. 10 mm³ of the removed nectar was given to each bee with a syringe. The bees fed in this manner soon died, with a 100 % knock-down being recorded on the 3rd day after the feeding, whereas no cases of mortality were recorded among the control bees until 18 days afterwards. A check was naturally made to determine whether it was the nectar itself that was poisonous to bees.

Lilium plants were treated in the same manner. As the weather conditions this time were rather bad for the absorption of the spray, the concentration was doubled, namely to 0.1 %.

With this species there was a high rate of mortality when bees were fed with the nectar yielded five days after the plants had been sprayed. It took only four days to obtain a 100 % kill.

These experiments showed that the flowers of plants treated with "OMPA" may yield poisonous nectar which is sufficiently toxic to kill visiting bees (Johnsen 1952 and 1953 a). This was ascertained later in England (Jones 1953) where in experiments conducted with radioactive "OMPA", poison was traced in nectar, honey and bees.

Experiments with "Systox"

(contains 50 % dialkylthiophosphonous anhydride and 50 % emulsifier)

Results given below were published in Danish literature (J o h n s e n 1953).

2 sets of 4 potted *Fuchsia hybrida* plants (room plant hybrids) were watered with "Systox" at the maximum concentration recommended by the manufacturers, i. e. 0.05 % aqueous solution. Each pot was given 75 ccs of the prepared solution, as specified in the directions for use. Nectar was removed from the flowers of each set of pots by means of a capillary tube after 5 and 20 days respectively. *Fuchsia* was selected purposely for this experiment because it yields large quantities of nectar per flower. Consequently no difficulties were experienced in quickly obtaining the desired amount of nectar. As soon as the nectar had been withdrawn from the treated plants, two batches of 30 and 40 bees respectively were fed with it, each bee being given a dose of 10 mm³. The bees were placed in batches of ten in small cages located in a thermostat heated to 32° C, with free access to a sugar-honey mixture and water. The same arrangement was used for a number of control bees.

The nectar withdrawn from the plants 20 days after they had been treated with "Systox" did not appear to have any influence on the longevity of the bees fed with it. It was not until the 17th and the 18th day after feeding that the first of the test bees and the control bees died. A period of 20 days does in fact more or less represent the time expected to be taken for the poison to disappear from the plant. The nectar taken from the flowers of the plants 5 days after they had been treated with "Systox" — namely at a time when it is expected that the sap contains poison — did not seem to have any effect either on the longevity of the bees fed with it judging from the comparison made with the longevity of the control bees. The first kills among the test bees occurred 16 days after feeding, and among the control bees after 15 days.

Even when the plants experimented on were given an overdosage of preparation, we did not succeed in causing a poisoning of bees with the technique used here.

It was not until a concentration of 0.5 % was applied (10 times the strength normally used for field sprays) that a poisoning effect was observed, when the bees had each consumed 10 mm³ of the nectar taken from the treated plants.

In view of this there seems to be a difference between "OMPA" and "Systox", because when applied at a normal dosage "OMPA" apparently contaminates the nectar whereas "Systox", judging by the results of these experiments, does not contaminate the nectar when applied at the standard concentration.

In horticultural and agricultural practices, the insecticide is applied by spraying and not by sprinkling. The strength recommended for field sprays is 0.05 % but this will most likely mean a smaller dosage than the one to which the plants were exposed in the experiments. Consequently it appears that there are no grounds to fear that bees will be poisoned by "Systox" provided it is not applied when the flowers are in bloom. However if the preparation is sprayed into the open blossom which shortly afterwards is visited by bees, then the bees will no doubt be poisoned. This was witnessed in Denmark where in one particular instance the treatment of a forest culture resulted in a poisoning of bees visiting blossoming raspberry (*Rubus idaeus*) which had been wetted by the spray. It is claimed that "Systox", as soon as the spray

deposit has dried on the plants, is evaporated and absorbed so that the poison cannot be washed off the plant surface. There is hardly any likelihood that plant growers will use concentrations higher than the recommended maximum particularly as the spray is rather expensive.

Tests of a purely exploratory nature were conducted to determine whether bees fed with pollen taken from a plant treated with "Systox" would be poisoned. In one instance pollen was brushed off the anthers of cultivated hyacinths (*Hyacinthus orientalis*), and mixed with a little honey. 4 bees ate the mixture without revealing any symptoms of poisoning.

In another test, a bunch of stamens taken from *Fuchsia*, with ripe pollen on the anthers, was placed in a cage containing 6 bees. This was done in such a manner as to ensure that the cut surface of the stalks from where the sap might run out, was not accessible to the bees. The result was that there were no cases of abnormal mortality among these bees either.

Consequently it may be concluded that the pollen is harmless to bees when "Systox" is applied in the normal manner although further investigations are necessary in order to completely clarify this point.

Experiments have also been conducted in Sweden (Wahlin 1953) to establish whether "Systox" is toxic to bees. These experiments revealed that "Systox" is extremely poisonous to bees if they come into direct contact with the spray. In digestibility trials, the bees reacted to very small quantities of "Systox". An unusually early mortality among the control bees proved to be due to small quantities of the substance being left in the cages even after they had been washed out following experiments with "Systox".

Experiments with "Systox" and bees have also been reported from Germany (Stute fide Hammarlund). The results of these experiments also reveal that "Systox" does not poison the nectar.

Field experiments have shown that cases of poisoning occur when bees fly onto fields which are in the process of being sprayed or half an hour after they have been treated. When the preparation is applied while there are no bees in the field — early morning or late evening — there should be no danger of poisoning.

Results of tests with the same conclusions as those drawn above were published in the U.S.A. (Eckert 1954) after the completion of this paper. In these tests, several thousand acres of cotton were treated with only one report of material damage.

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Control of Yellows in Rheinland-Pfalz in 1953

By Dr. L. Rump

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For many years a close watch has been kept on yellows occurring in beets in the sugar beet growing areas of Rheinland-Pfalz. Up to 1951 this disease only occurred sporadically, and gave no special cause for anxiety. In 1952, however, which was a dry year, yellows occurred on what was from an economical aspect a most extensive and alarming scale in the districts of Worms, Frankenthal, Ludwigshafen and Speyer. Unquestionably the sudden and extremely widespread propagation of the disease was linked with the weather prevailing during the summer months — this was very favourable for the development of the aphid species *Myzodes*, *Doralis* and *Macrosiphon* — and the weakened physiological constitution of the beets resulting from the dry weather. Even during the summer of 1952 it was already clear to growers and plant protection officials in those districts affected that drastic measures would have to be taken against yellows on sugar beets if sugar beet farming in those areas of Rheinland-Pfalz threatened by the disease were not to be brought to a standstill.

Conditions were in favour of the development of yellows in the sugar beet growing districts between Worms and Speyer in so far as winter spinach is also grown on a large scale in these areas which are also important for the cultivation of field vegetables. Since spinach is infested by yellows to the same extent as beets, and in certain cases is still growing in the fields at a time when the beets have already emerged, added to which the climate of this region favours the occurrence of the first generations of the different aphids species, great significance must, therefore, be attached to spinach growing with respect to the transmission of yellows to sugar beets. Likewise a part of no small importance is also played by peaches and cabbage, grown on a fairly large scale, in the transmission of yellows by *Myzodes persicae*.

The region in Rheinland-Pfalz which suffered particularly from yellows in 1952 stretched in a North-South direction from Osthofen to Limburgerhof, and in an East-West direction from the Rhine to a line joined together by the villages of Pfeddersheim, Neuoffstein, Dirmstein, Maxdorf, Dannstadt (see map, Fig. 1). Outside the boundaries of this area, the disease occurred more or less heavily in beet fields but on a cluster scale. It is reported that the main area of infestation East of the Rhine stretched as far as a few kilometres away from the West side of the Bergstraße. Judging by the situation at the end of August 1952, it was estimated that approx. 2500 hectares of beet fields were heavily infested in Rheinland-Pfalz. A further 6000 hectares had to be regarded as being threatened by the disease as a result of the heavy occurrence on a cluster scale. This means that from the total sugar beet growing area of Rheinland-Pfalz, approx. 20 % was very heavily infested and a further 50 % was seriously threatened, whereas the remaining 30 % was for the time being out of danger.

The gloomy predictions that yellows would continue to spread in 1953 unfortunately proved true, because in that year approx. 6000 hectares of the sugar beet growing area of Rheinland-Pfalz were totally infested, and parts of at least another 2000 hectares were very heavily infested. The area of infestation

Fig. 1



Fig. 1. Area of yellows infestation in Rheinland-Pfalz.
1952 Boundary: - - - - - 1953 Boundary: - . - . -

had extended to the North almost as far as the periphery of Mainz, and to the South well into the district of Germersheim. In the East the infestation had spread far into the district of Alzey where the sugar beet fields were all completely infested by yellows (see map, Fig. 1).

A survey of the increase of yellows in Rheinland-Pfalz, therefore, produces the following picture in percentage of the total beet growing area.

	1952	1953
Total infestation	20 %	50 %
Heavy infestation on cluster scale	50 %	20 %
Not infested	30 %	30 %

In view of the economic significance attached to sugar beet yellows with respect to the yield loss of beets and beet leaves and the decrease in the sugar content of the beets, all parties involved realized from the outset that drastic measures would have to be taken in 1953 to stem the disease.

A calculation of the damage suffered in 1952 by the sugar beet industry as a result of yellows provides the following picture based on precise records which due to the limited scope of this paper cannot be given in full detail:

A. Harvest Losses:

a) 30 % yield loss of beets with an average harvest of 27 metric tons per hectare = 8.1 metric tons at 63.00 DM	510.30 DM
b) 30 % loss beet leaves with an average harvest of 18 metric tons per hectare = 5.4 metric tons at 12.00 DM	64.80 DM
c) Loss of dry pulp = 4.5 % of the beets supplied = 0.364 metric tons per hectare at 140.00 DM	50.96 DM
Total harvest losses per hectare	626.06 DM
For 2500 hectares of beets infested by yellows, there was a total loss of	<u>1 565 150.00 DM</u>

B. Sugar Losses:

a) Loss of sugar yield with a yield loss of 8.1 metric tons per hectare and an average polarization of 15.63 %	1 266.0 kg
b) 1.3 % decrease of the sugar content caused by yellows for a residual harvest of 18.9 metric tons of beets per hectare	245.7 kg
Total sugar loss per hectare	1 511.7 kg
Total sugar loss on 2500 hectares of beet fields infested by yellows	<u>37 792.5 kg</u>
The value of this reduced sugar yield, based on a price of 73.12 DM per 100 kg of sugar (less tax, trade margin and freight equalization) amounts to	<u>2 763 387.60 DM</u>



Fig. 2. Beets freed from aphids following two "Systox" sprays.

Photo : Dr. Rump, Mainz

Therefore, in 1952 on 2500 hectares of beet fields totally infested by yellows there were losses caused by

harvest decreases amounting to	1 565 150.00 DM
and sugar losses amounting to	2 763 387.60 DM
Total:	<u>4 328 537.60 DM</u>

This results in a sum of 1 731.40 DM per hectare of infested beet growing area. In addition, there are also the losses which simply cannot be calculated caused by decreases of the white sugar yield resulting from processing beets with a low sugar content.

As already mentioned above, the yellows disease was spread in 1953 over 6000 hectares of totally infested fields and 2000 hectares of fields which were partially severely infested. On the other hand, however, an aphid control was successfully carried out on approx. 1000 hectares in the main infestation area and considerable damages due to harvest losses or sugar content losses in the control area were not observed, with the result that the total damage inflicted in 1953 amounted to:

A) Harvest Losses:

a) Harvest loss of beets	
= 7.2 metric tons per hectare at 72.00 DM	518.40 DM
b) Harvest loss of beet leaves	
= 8 metric tons per hectare at 12.00 DM	96.00 DM
c) Loss of dry pulp (4.5 % of supplied beets)	
= 0.324 metric tons at 140.00 DM	45.36 DM
Total:	<u>659.76 DM</u>

Accordingly, on 5000 hectares of beet fields there was a harvest loss amounting to

3 298 800.00 DM

B. Sugar Losses:

a) Total loss of sugar for 7.2 metric tons per hectare of beets with 17.4 % sugar at 73.12 DM per 100 kg on 5000 hectares	4 580 000.00 DM
b) 1 % sugar content decrease on 5000 hectares	1 038 528.00 DM
c) Pulp loss of 1.5 % for 7.2 metric tons per hectare at 14.00 DM	75 600.00 DM
	<u>5 694 128.00 DM</u>

Therefore, in 1953 total losses on 5000 hectares of totally infested fields were caused by

harvest decrease amounting to	3 298 800.00 DM
and sugar losses amounting to	5 694 128.00 DM

Total: 8 992 928. DM

This results in a sum of 1 798.60 DM per hectare of beet growing area. On the other hand a loss of approx. 1.8 million DM was avoided by spraying the 1000 hectares of beet fields with "Systox" as a control measure against the aphids. The above calculations represent the extreme minimum damage actually caused by yellows in 1952 and 1953. This point is particularly stressed because according to the result of 260 yield determinations and polarizations the average losses were as follows:

Beet weight	30.6 %
Leaf mass	30.3 %
Sugar content	1.4 %

Moreover, no allowance has been made for the sugar beet fields located on the boundaries of the main area of infestation, some of which were partially heavily infested. *

The investigations carried out over the past few years by Steudel and co-workers, have shown that the plant protection service now has available a highly active preparation, namely the systemically effective aphicide "Systox", which although even when applied in good time does not prevent the development of yellows during the course of beet vegetation, does, however, considerably mitigate the economic consequences with respect to yield losses and losses of sugar content. A condition for this, however, is that the sprays are carried out as early as possible when the beets are first colonized by aphids. Moreover, the sprays should be repeated a short time later in order to exterminate virus-carrying aphids, too, which fly on to the sprayed areas. Later on in the season, from about the middle of June until the end of August, virus-transmitting aphids are said to be able to pass on the yellows disease to the beet plants they attack, although such late infections are apparently of secondary significance with respect to yield losses or decreases in the sugar content of the beets.

In view of the economic importance which unquestionably must be attached to sugar beet yellows on the basis of the calculations with respect to losses given above, and considering the danger it presents to sugar beet growing

as a whole, the sugar industry and supplies of inland sugar to the population, it was greatly welcomed on all sides when the Federal Ministry of Food, Agriculture and Forestry, in particular the Department for Plant Protection under Dr. Drees, officially took up the problem of controlling yellows, and smoothed the way for the application of "Systox" on a wide basis. In addition the Federal Ministry of Food, Agriculture and Forestry made available a large sum for purchasing spraying equipment, thus rendering it possible to procure for Rheinland-Pfalz 40 field sprayers (Mauser) with a swath of 5 m, and 10 power sprayers with a swath of 10 m (manufactured by Messrs. Platz, Holder, Fricke and Pflanzenschutzgeräte G.m.b.H.).

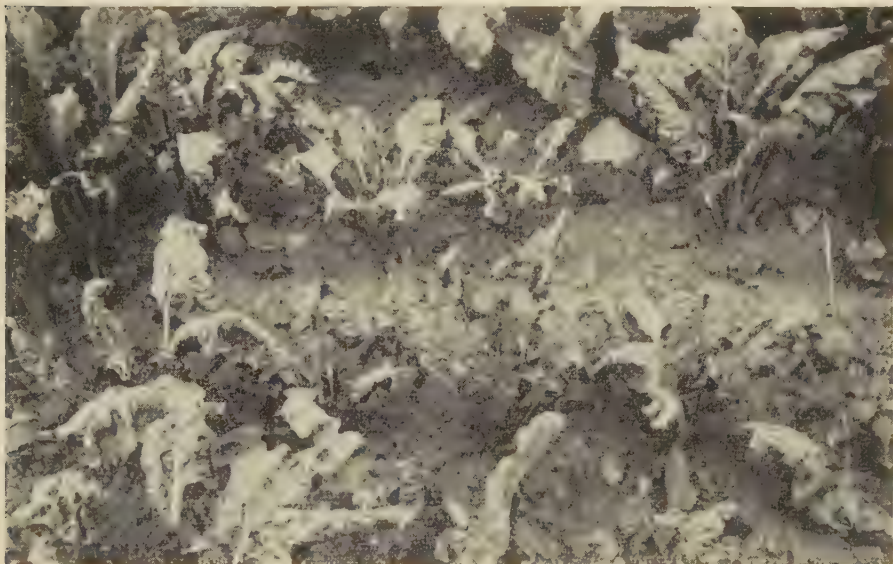


Fig. 3. Check rows in the field shown in Fig. 2 which were left untreated. Very severe aphid infestation (*Durastis fabae*).

Photo: Dr. Rump, Mainz

The Ministry for Agriculture, Viticulture and Forestry of Rheinland-Pfalz, fully appreciating the threatening danger, and acting on the instructions of Herr Stübinger, Minister of State, also made a contribution to the control costs amounting to 12.00 DM per hectare of treated area, while the Provincial Department for Pest Control of Rheinland-Pfalz undertook to pay all expenses for the department's own personnel engaged in the organisation and supervision of the control.

In order to drive home to the beet growers the necessity of systematic and comprehensive measures for controlling yellows, this subject was discussed in detail at many farmers' meetings held immediately following the beet harvest in 1952. The sugar beet growers' union, the local sugar industry, the agricultural colleges at Worms, Frankenthal and Speyer located in the infested area, and the Provincial Department for Pest Control took advantage of every

available opportunity to deal thoroughly with this very important question. In this way one of the most important conditions for the success of measures taken to control plant diseases was fulfilled, namely to convince the farmers that something fundamental and methodical would have to be done. Once the growers had been made to realize how urgent the matter was, they showed their willingness to co-operate by contributing 50.00 DM per hectare of treated beet growing area towards the costs.

Once these preparations had been completed and as soon as the first aphids were found on the beet plants during the last few days of May, the control action was started as planned on May 28. The rainy and windy



Fig. 4. "Mauser" tractor-drawn sprayer with a swath of 5 m. Tractor driver equipped with respirator and rubber gloves.

Photo: Dr. Rump, Mainz

weather, however, which at times was most unfavourable for spraying, held up the last spray of the second series until July 6. Altogether 824.5 hectares of beet fields were sprayed twice with "Systox" at the rate of 400 litres per hectare. A 0.1% concentration was used, this being equal to 400 grammes of "Systox" per hectare for each spray.

The amount of work that can be accomplished with the types of sprayers used is also an interesting factor. The outputs per working day, including time taken for moving the sprayers from one location to another, filling, maintenance of the equipment and any small repairs rendered necessary during spraying, amounted to:

approx. 8 hectares per tractor-drawn or power sprayer and

approx. 12 hectares per Alldog sprayer type (these types were made available by the Central Receiving Depot for sugar beet, in addition to the other types).

Mention should be made of the precautionary measures which have to be observed when handling the toxic preparation "Systox" and which make it all the more difficult to carry out spraying, in particular the exclusive use of tractors to tow the sprayers and the wearing of protective suits and respirators by all personnel directly engaged in spraying. These, however, are not the only factors which involve difficulties when spraying beet fields with "Systox"; the treated fields have to be marked, such tasks as thinning out and hoeing the beets in the sprayed fields have to be restricted, and limits are even set to the utilization of neighbouring fields in which either fodder crops or vegetables are grown.



Fig. 5. "Platz" type power sprayer with 10 m swath.

Photo: Dr. Rump, Mainz

The total costs incurred in 1953 for 824.5 hectares of treated area were:	
for "Systox"	DM 52 688.00
„ wages, social insurance, hiring of tractors, water conveyance, travelling expenses and cartage	DM 24 731.75
„ water supply, repairs, fuel, freight	DM 3 567.32
„ postage, telephone, advertisements, printed matter, public notices	DM 854.22
„ miscellaneous (respirators, protective clothing, rubber gloves, measuring vessels)	DM 1 513.03
Total:	<u>DM 83 354.32</u>

This means that on the average the total costs amounted to approx DM 100.— per hectare of area sprayed twice. The success of carrying out two

sprays with "Systox" must be regarded as extremely satisfactory because the numbers of beetles in the field heavily infested by yellows provide the following picture when expressed in %:

Field No.	in stocks sprayed twice	check in untreated stocks
1	12.75 %	66.50 %
2	29.80 %	80.00 %
3	27.50 %	60.10 %
4	13.80 %	87.00 %
5	18.30 %	85.75 %
6	10.80 %	16.00 %
Average:	18.82 %	65.89 %



Fig. 6. Operator wearing respirator and rubber gloves while handling "Systox"

Photo: Dr. Rump, Mainz

The success of two sprays is also confirmed when the weight and the sugar content of 5 beets sprayed twice are compared with weight and sugar content of untreated beets taken from the check stocks:

Field Number	Weight of 5 beets in kg		± sprayed, compared with untreated	Sugar content in %		± sprayed, compared with untreated
	sprayed twice	untreated		sprayed twice	untreated	
1	5.6	3.6	+ 2.0	17.4	16.2	+ 1.2
2	6.7	3.1	+ 3.6	16.7	15.6	+ 1.1
3	5.0	5.6	— 0.6	17.5	15.4	+ 2.1
4	4.9	3.2	+ 1.7	14.7	14.3	— 0.4
5	6.7	3.9	+ 2.8	17.5	15.8	+ 1.7
6	4.8	3.4	+ 1.4	15.6	15.4	+ 0.2
7	6.4	4.3	+ 3.1	17.7	17.1	+ 0.6
8	5.0	2.6	+ 2.4	17.7	17.1	+ 0.6
9	4.9	2.4	+ 2.5	17.1	16.4	+ 0.7
10	4.9	3.6	+ 1.3	17.2	15.0	+ 2.2
11	2.7	2.8	— 0.1	16.7	16.5	+ 0.2
Average:	5.23	3.50	+ 1.73	16.9	15.9	+ 1.0

These figures show that control measures taken against yellows, and particularly when they are carried out in good time, will always be crowned with success, and in fact must always be recommended without the slightest restriction. Even though the control costs appear at first sight to be unusually high, the data given above show that it is extremely worth while to meet such costs, especially when it is considered that this expenditure only amounts to approx. 12 % of the increased yields of harvest and sugar rendered possible by controlling yellows.

Application of "Bulpur" on Onions, 1954

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"Bulpur" is used to control weeds occurring in onion rows. A report is given in this paper on recent tests carried out with this preparation.

Bulpur was tested on onions at different localities, being applied in a concentration of $1\frac{1}{2}$ % and 2 % (1000 litres of water per hectare) shortly prior to emergence, and when the plants had grown to a height of 15 cm. All the test plots were specially drilled, and arranged in a Latin rectangle (4 replications).



Untreated onions

The amount sown corresponded to that conventional in the locality; the same applied to fertilisation. A space of 20 cm was left between rows. A 10 litre capacity knapsack sprayer with a spraying pressure of 5 atmospheres gauge was used to apply the preparation. For technical reasons, the harvest yield could not be determined, so that the report is confined to data on the herbicidal effect of "Bulpur".

Pre-emergence application of "Bulpur"

The first treatment with 2 % "Bulpur" was carried out on onion plots barely four weeks after they had been drilled. The onions were in the stage

immediately prior to emergence. The weeds present chiefly included white goosefoot, persicary and fumitory in the process of penetrating the top layer, giving the impression of a thin covering of mildew. The average temperature was 10° C. One week later, the untreated plots were heavily colonized by weeds, with *Chenopodium album* in the majority. 2 % "Bulpur" was particularly effective against goosefoot which did not emerge until late, and then only sporadically. It was most noticeable that fumitory germinated quite well despite the spraying, although not in such large numbers as in the untreated plots. The emerging rows of onions were uniform, and later on the stock was comparable with the hoed check plots. By the middle of May, the soil effect of "Bulpur" could be observed extremely well (see photographs). The treated rows were now ready



Onions after treatment with 2% "Bulpur"

to be hoed for the first time, while in the untreated plots, the onion rows were completely covered by a canopy of weeds.

Post-emergence application of "Bulpur"

On June 7th, "Bulpur" was sprayed at a concentration of 1½ % and 2 % on onions which had now reached a height of approximately 15 cm. Spraying was preceded by hand-hoeing. In the meantime the weeds had reached the large rosette stage, and in fact certain weeds had already passed it. Orache and fumitory proved to be very resistant, and suffered no damage even following

an application of 2 %. The effect against persicary and creeping thistle was extremely good. In most cases, serious scorching was caused despite the fact that the ability to regenerate was great due to the favourable weather conditions prevailing in 1954. Chickweed was slightly damaged, while charlock and moneywort were practically eradicated.

The one year observations show, in passing a cautious opinion, that a soil spray keeps the ground free from germinating weeds over a long period, and the first hand-hoeing can be carried out much later than usual. It would seem that a treatment of onions in a later stage of growth can only be carried out successfully provided that the weeds occurring at the time the spray is applied have not yet passed the large rosette stage.